Results of the March-April 2004 Echo Integration-Trawl Surveys of Walleye Pollock (*Theragra chalcogramma*) Conducted in the Gulf of Alaska, Cruise MF0403

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INTRODUCTION

Scientists from the Midwater Assessment and Conservation Engineering (MACE) Program of the Alaska Fisheries Science Center (AFSC) routinely conduct echo integration-trawl (EIT) surveys in the Gulf of Alaska (GOA) during late winter and early spring to estimate walleye pollock (*Theragra chalcogramma*) distribution and abundance. Most of the effort has focused on the Shelikof Strait area, which has been surveyed annually since 1980, except in 1982 and 1999. Surveys were also conducted in the Shumagin Islands area in 1994-96 and 2001-02 and along the GOA shelf break east of Chirikof Island in 2002-03. Results presented here are from EIT surveys carried out during March and April 2004 in the Shelikof Strait area and along the GOA shelf break near Chirikof Island.

METHODS

Acoustic Equipment

Acoustic data were collected with Simrad EK500¹ (ROMS 5.30) and Simrad ER60 (version 2.0.0) quantitative echosounding systems (Simrad, 2001; Bodholt et al. 1989) on the NOAA ship *Miller Freeman*, a 66-m stern trawler equipped for fisheries and oceanographic research. Four split-beam transducers (18, 38, 120, and 200 kHz) were mounted on the bottom of the vessel's retractable centerboard extending 9 m below the water surface. System electronics were housed inside the vessel in a permanent laboratory space dedicated to acoustics. Acoustic data were collected at 38 and 120 kHz frequencies with the EK500 echosounder and at 18, 38, 120, and 200 kHz with the ER60 system. A custom-designed multiplexer was used to alternate pings between the EK500 and ER60. Acoustic data were logged using SonarData EchoLog 500 (version 3.10.16.0) and ER60 software. Data were analyzed using SonarData Echoview post-processing software (version 3.10.129). Echo integration and target strength (TS) data were collected simultaneously for all sounder-transducer combinations. Results presented here are based on the 38 kHz data collected with the EK500 echosounder.

Trawl Gear

Midwater and near-bottom echosign were sampled using an Aleutian Wing 30/26 Trawl (AWT). This trawl was constructed with full-mesh nylon wings and polyethylene mesh in the codend and aft section of the body. The headrope and footrope each measured 81.7 m (268 ft). Mesh sizes tapered from 325.1 cm (128 in) in the forward section of the net to 8.9 cm (3.5 in) in the codend. The net was fitted with a 3.2-cm (1.25-in) codend liner for the Shelikof Strait survey and a 1.3-cm (0.5-in) codend liner for the Chirikof survey. The AWT was fished with 82.3 m (270 ft) of 1.9-cm (0.75-in) diameter (8x19 wire) non-rotational dandylines, 226.8-kg (500-lb) tom weights on each side, and 5 m² Fishbuster trawl doors [1,247 kg (2,750 lb) each]. Vertical net opening and depth were monitored with either a Wesmar third-wire or Furuno netsounder system attached to the trawl headrope. The vertical net opening for the AWT trawl ranged from 16-32 m (49-82 ft).

Demersal echosign was sampled with a poly nor'eastern bottom trawl (PNE) with roller gear. The PNE is a high-opening trawl equipped with roller gear and constructed with stretch mesh sizes that ranged from 13 cm (5 in) in the forward portion of the net to 89 mm (3.5 in) in the codend. The codend was fitted with a 3.2 cm (1.25 in) nylon mesh liner. The 27.2-m (89.1-ft) headrope held 21 floats [30-cm (12-in) diameter]. A 24.7-m (81-ft) chain fishing line was attached to a 24.9-m (81.6-ft) footrope constructed of 1-cm (0.4-in) 6 x 19 wire rope wrapped with polypropylene rope. The trawl was also rigged with triple 54.9-m (180-ft) galvanized wire rope dandylines. The roller gear was attached to the fishing line using chain toggles [2.9 kg (6.5 lb.) each] comprised of five links and one ring. The 24.2-m (79.5-ft) roller gear was constructed with 36-cm (14-in) rubber bobbins spaced 1.5 to 2.1 m (5 to 7 ft) apart. A solid string of 10-cm (4-in) rubber disks separated some of the bobbins in the center section of the roller gear. Two 5.9-m (19.5-ft) wire rope extensions with 10-cm (4-in) and 20-cm (8-in) rubber disks were used to span the two lower flying wing sections and were attached to the roller gear. The net was fished with the 5-m² Fishbuster trawl doors. The vertical net opening and depth were monitored

¹ Reference to trade names or commercial firms does not constitute U.S. Government endorsement.

with a Furuno netsounder system attached to the headrope. The PNE trawl vertical mouth opening ranged from 5-7 m (20-26 ft).

Oceanographic Equipment

Physical oceanographic data collected during the cruise included temperature/depth profiles obtained with a Sea-Bird Electronics temperature-depth probe (SBE-39) attached to the trawl headrope and conductivity-temperature-depth (CTD) observations collected with a Sea-Bird CTD system at the calibration sites. Sea surface temperature, salinity, and other environmental data were collected using the *Miller Freeman*'s Scientific Computing System (SCS).

Survey Design

Parallel transect designs were used in both areas surveyed. The Shelikof Strait sea valley was surveyed from about Cape Chiniak on the Alaska Peninsula to south of Chirikof Island between 25-30 March using 13.9 km (7.5 nmi) transect spacing (Fig. 1). Transects generally did not extend into waters shallower than about 100 m depth. A survey of the shelf break southeast of Chirikof Island to near the mouth of Barnabas Trough was conducted between 31 March-1 April along 14.8 km (8 nmi) spaced transects (Fig. 1). Bottom depths generally ranged from 200 m to 1,000 m.

Trawl hauls were conducted to identify echosign, to provide biological samples for the primary goals of the survey, and to collect specimens for additional research projects such as fecundity and genetic studies. Average trawling speed was approximately 1.5 m/s (3 kts). Pollock were sampled to determine sex, fork length (FL), body weight, age, maturity, and ovary weight of selected females. Fork lengths were measured to the nearest centimeter (cm). An electronic motion-compensating scale was used to weigh individual pollock. For age determinations, pollock otoliths were collected and stored in 50% ethanol-water solution. Maturity was determined by visual inspection and categorized as immature, developing, pre-spawning, spawning, or post-spawning. All data were electronically recorded using the Fisheries Scientific Computing System (FSCS) developed by NOAA's Office of Marine and Aviation Operations to digitally collect data aboard research vessels. Data were stored in a relational database.

Additional samples of pollock tissue, ovaries, and stomachs were collected for ongoing research by AFSC scientists. Whole fish were frozen for AFSC Observer Program training specimens.

Standard sphere acoustic system calibrations were conducted to measure acoustic system performance for the EK500 (38 and 120 kHz) and for the ER60 (all frequencies). During the calibrations, the *Miller Freeman* was anchored at the bow and stern. A tungsten carbide sphere (38.1 mm diameter; 38, 120 and 200 kHz) and a copper sphere (64 mm diameter; 18 kHz) were suspended below the centerboard-mounted transducers. Split-beam target strength and echo integration data were collected with each sphere centered on the acoustic axis to determine acoustic system gain parameters. The beam pattern was estimated by moving each sphere through a grid of angle coordinates and collecting TS data using the Simrad software program EKLOBES (Foote et al. 1987).

Data Analysis

Echo integration data were collected between 14 m of the surface and 0.5 m of the bottom, except where the bottom exceeded 1,000 m, the lower limit of data collection. Echosign data identified as pollock were stored in a relational database. Pollock length data were aggregated into analytical strata based on echosign type, geographic proximity of hauls, and similarity in size composition data. Estimates of pollock backscattering strength for each stratum were then calculated using an S_v threshold of -70 dB. The echo integration values were summed and scaled using a previously derived relationship between TS and fish length (TS = 20 Log FL - 66; Traynor 1996) and length composition data to produce estimates of pollock numbers by length. Biomass estimates were calculated applying a length-weight relationship based on mean weights by 1-cm length intervals. Age-specific estimates of biomass and numbers will be generated after the otolith samples are aged.

Large numbers of eulachon (*Thaleichthys pacificus*) contaminated the acoustic returns from pollock in the Shelikof Strait area. The acoustic sign between these two species was apportioned using the catch weight of the two species in a manner described by Guttormsen et al. (2001).

Relative estimation errors for the acoustic data were derived using a one-dimensional (1D) geostatistical method as described by Petitgas (1993), Williamson and Traynor (1996), and Rivoirard et al. (2000). Relative estimation error is defined as the ratio of the square root of the estimation variance to the estimate of acoustic abundance. Geostatistical methods were used for computation of error because they consider the observed spatial structure. These errors quantify only transect sampling variability. Other sources of error (e.g., target strength, trawl sampling) are not included.

RESULTS AND DISCUSSION

Calibration

Two acoustic system calibrations were conducted prior to the survey period (Table 1). The EK500 38-kHz and 120-kHz collection systems showed no significant differences in gain parameters or transducer beam pattern characteristics between the calibrations. Following the Chirikof survey, the *Miller Freeman*'s centerboard struck a reef, resulting in the loss of the transducer array; thus no post-survey calibration was conducted.

Shelikof Strait

Biological Sampling

Biological data and specimens were collected in the Shelikof Strait from 13 AWT hauls and 2 bottom trawl hauls (Table 2, Fig. 1). Pollock and eulachon were the most abundant species by weight in midwater trawl hauls, comprising 88% and 10% of the total catch (Table 3). Pollock comprised 60% of the catch in the bottom trawls, with arrowtooth flounder (*Atheresthes stomias*, 23%), eulachon (4%), and big skate (*Raja binoculata*, 3%) comprising most of the bycatch (Table 4).

Distribution

Acoustic data were collected along 1,221 km (659 nmi) of transect tracklines. For the first time since 2000, significant amounts of pre-spawning pollock were detected in the Shelikof Strait area from Cape Kuliak to Cape Kekurnoi, although in lower abundance than during the mid-to late-

1990s (Fig. 2). Significant quantities of adult pollock² were also detected just outside the mouth of the strait off Middle Cape. Midwater layers of sub-adult pollock, sometimes in the form of tight schools at about 50-75 m depth, were found on some transects, particularly within the strait proper (Fig. 3).

Length Composition

Trawl hauls conducted in the densest pollock echosign contained a mixture of fish likely from the 1999 year class (35-40 cm FL), which has dominated population estimates of recent Shelikof Strait surveys, and older fish, although relatively few fish exceeded 50 cm FL (Figure 4A). Younger fish (≤30 cm FL) were only prevalent in the southern portion of the survey area (Figure 4B). Fish caught in trawl hauls conducted in the mid-water layer mostly ranged from 30-40 cm FL (Figure 4C).

Maturity

The unweighted maturity composition in the Shelikof Strait area for males longer than 40 cm was 1% immature, 1% developing, 68% mature pre-spawning, 29% spawning, and 1% spent (Fig. 5A). The female maturity composition of fish longer than 40 cm was 3% immature, 13% developing, 77% pre-spawning, 5% spawning, and 1% spent (Fig. 5B). These results are similar to previous survey results in terms of low numbers of spawning and spent fish and suggest that the survey timing was appropriate. A logistic model provided a reasonable fit to the female maturity at length data and predicted that 50% of females were mature at a length of 34 cm FL (Fig. 5C), which is shorter than estimates since 1985 but similar to the 1983 and 1984 estimates of 37 and 38 cm FL. The average GSI for pre-spawning females of 0.16 (Fig. 5D) was higher than in 2002 (0.12) and 2003 (0.11) but similar to the mean GSIs (0.14-0.19) reported for other recent (1992-2001) surveys.

Abundance

²Because age data are not yet available, length ranges were used as a proxy for age based on length at age from previous surveys. Pollock between 9-16 cm FL are considered 1-year olds, most pollock between 17-25 cm FL are considered 2-year olds, most pollock from 26-30 cm FL are considered 3-year olds, most pollock from 31-34 cm FL are considered 4-year olds, and most pollock exceeding 34 cm FL are considered adults.

The abundance estimate is 631 million pollock weighing 291 thousand t. The estimates include adjustments for backscattering attributed to eulachon. The relative estimation error of the biomass based on the 1D analysis of echosign was 9.2%.

The 1994 year class, which represented the largest estimate of 1-year old pollock (10.0 billion fish) in the history of the Shelikof Strait area EIT surveys and dominated Shelikof abundance estimates through 1998, effectively disappeared by 2004 (Fig. 6). The 1999 year class (4.3 billion fish in 2000) was the second largest 1-year old estimate in survey history and has dominated abundance estimates, in both numbers and biomass, since 2001. The estimate of 1-year old pollock in 2004 of 14 million fish is one of the lowest estimates in survey history and suggests that the 2003 year class is weak.

The pollock biomass in Shelikof Strait declined dramatically in the 1980s, falling from 2.8 million t in 1981 to 290 thousand t in 1989 (Fig. 7). The biomass gradually rose in the 1990s, reaching 748 thousand t in 1996. Since then, the population has declined to its current level of 291 thousand t.

Shelf break area near Chirikof Island

Biological Sampling

Biological data and specimens were collected near Chirikof Island from 4 AWT hauls (Table 2). Pollock (99%) comprised most of the catch (Table 5).

Distribution

Acoustic data were collected along 224 km (121 nmi) of transect tracklines. Most of the echosign attributed to pollock along the shelf break near Chirikof Island occurred in mid-water layers between 275-500 m depth in the shelf-break bight between W154° and W155° over bottom depths of 350-800 m (Fig. 8). Substantial acoustic backscattering was attributed to myctophids and other micronekton species, which occurred along the offshore portions of the transects at about 200-300 m depth. This myctophid scattering layer, which occurred mostly

over bottom depths from 800 m to deeper than 1,500 m, may have obscured low densities of pollock.

Length Composition

Most of the pollock were shorter than 50 cm FL (Fig. 4D), which differed from the 2002 and 2003 survey results, when most pollock were longer than 50 cm FL. No fish shorter than 35 cm FL were caught during the survey.

Maturity

The unweighted maturity composition for males longer than 40 cm in the Chirikof Island area survey was 19% immature, 10% developing, 60% mature pre-spawning, 6% spawning, and 4% spent (Fig. 9A). The female maturity composition of fish longer than 40 cm was 0% immature, 65% developing, 32% pre-spawning, 2% spawning, and 1% spent (Fig. 9B). The low percentage of female spawners and post-spawners (3%) indicates that peak spawning had not yet occurred. The high ratio of developing to mature pre-spawning females is consistent with previous survey results where the majority of fish are in the 40-45 cm FL range. A logistic model provided a reasonable fit to the female maturity at length data and predicted that 50% of females were mature at a length of 48 cm FL (Fig. 9C). The average GSI for pre-spawning females was 0.18 (Fig. 9D).

<u>Abundance</u>

The abundance estimate is 45 million pollock weighing 30 thousand t. The relative estimation error of the biomass based on the 1D analysis of echosign was 20.7%. The biomass in 2004 was similar to the 2003 estimate of 31 thousand t but 63% lower than the 82 thousand t estimated in the same area in 2002.

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procedure to fisheries acoustic surveys of Alaskan pollock. ICES J. Mar. Sci. 53: 423-428.

Table 1. Results from acoustic system calibrations of the EK500 associated with the early spring 2004 echo integration-trawl surveys of walleye pollock in the Gulf of Alaska.

					Sphere			3-dB	3-dB Beam	An	Angle
		Frequency	Water temp (°C)	(°C)	range from	TS gain s _v gain	s _v gain	width	width (deg)	offset	offset (deg)
Date	Date Location	(kHz)	At transducer ¹	At sphere	transducer (m)	(dB)	(qB)	Along	slong Athwart	Along	Along Athwart
18-Mar	18-Mar Port Susan, WA	38	8.9	9.8	19.2	26.8	26.4	7.14	66.9	-0.27	-0.01
		120	8.9	8.6	20.0	27.9	27.9	6.53	6.48	0.23	0.04
24-Mar	24-Mar Izhut Bay, AK	38	4.6	4.7	24.9	26.7	26.5	66.9	6.84	-0.25	-0.01
		120	4.6	4.7	24.7	27.5	27.7	69.9	09.9	0.25	0.02
	System settings	38	1	1		26.8	26.5	96.90	08.9	0.00	0.00
	during surveys	120	-	-	1	27.7	27.7	7.10	7.00	0.00	0.00

¹The transducer was located approximately 9 m below the water surface.

Note: Gain and beam pattern terms are defined in the "Operator Manual for Simrad EK500 Scientific Echo Sounder (1993)" available from Simrad Subsea A/S, Strandpromenaden 50, P.O. Box 111, N-3191 Horten, Norway.

Table 2. Trawl station summary from the early spring 2004 echo integration-trawl survey of walleye pollock in Shelikof Strait (hauls 1-15) and near Chirikof Island (hauls 16-19).

<u>ch</u> Other	ber kg		991 19	329 6	2,218 1	300 8	231 3	830 31	947 9		0				083 18				6 0	8 0
Eulachon catch	kg number	_			69 2,														0	0
catch	number	1,348	1,309	3,645	1,187	3,022	1,360	3,748	1,710	885	2,169	1,441	1,628	1,580	999	1,123	9	869	1,084	2,211
Pollock catch	kg		330	1,966	582	1,525	629	2,133	656	144	805	703	903	792	188	249	9	450	<i>L L L L L L L L L L</i>	1,757
(m) u	Bottom	298	209	270	276	242	292	322	306	246	199	272	261	279	300	569	454	333	519	844
Depth (m)	Gear	298	173	244	261	199	224	282	286	246	70	240	246	271	288	245	357	324	322	251
	de (W)	20.62	15.73	5.88	7.91	57.15	49.20	53.08	53.11	45.50	55.58	22.93	20.64	53.63	18.44	53.62	47.90	5.30	50.13	21.03
Start Position	Longitude (156	156	156	156	155	155	155	155	155	155	155	155	154	155	154	154	154	153	153
Start 1	atitude (N)	82.6	51.66	57.84	51.67	43.27	45.69	35.83	30.41	19.94	8.66	15.02	5.84	51.96	40.49	12.77	41.68	52.94	57.59	50.88
	_	58	57	57	57	57	57	57	57	57	57	57	57	99	99	99	55	55	55	55
Ouration	(min)	12	15	11	5	33	B	2	4	15	56	9	25	20	8	10	28	17	4	11
Time I	(GMT)	2:45	8:01	11:48	19:37	1:47	7:56	10:48	14:04	2:16	6:50	11:42	17:05	17:36	2:13	16:17	12:14	16:50	19:56	4:10
	Date	26 Mar	26 Mar	26 Mar	26 Mar	27 Mar	27 Mar	27 Mar	27 Mar	28 Mar	28 Mar	28 Mar	28 Mar	29 Mar	30 Mar	30 Mar	31 Mar	31 Mar	31 Mar	1 Apr
Haul Gear ¹	. Type	PNE	AWT	AWT	AWT	AWT	AWT	AWT	AWT	PNE	AWT	AWT								
Haul	No.	1	7	κ	4	5	9	7	∞	6	10	11	12	13	14	15	16	17	18	19

¹AWT = Aleutian wing midwater trawl and PNE = poly nor-eastern bottom trawl

Table 3. Summary of catch by species in 13 midwater trawls conducted during the 2004 pollock echo integration-trawl survey of the Shelikof Strait area.

Common name	Scientific name	Weight (kg)	Percent	Numbers	Percent
Walleye pollock	Theragra chalcogramma	11,894.6	88.4%	24,494	40.9%
Eulachon	Thaleichthys pacificus	1,352.0	10.0%	34,199	57.1%
Arrowtooth flounder	Atheresthes stomias	86.1	0.6%	25	<0.1%
Majestic squid	Berryteuthis magister	70.2	0.5%	130	0.2%
Chinook salmon	Oncorhynchus tshawytscha	34.2	0.3%	22	<0.1%
Squid unident.	Teuthoidea (order)	6.9	0.1%	339	0.6%
Pacific cod	Gadus macrocephalus	5.4	<0.1%	1	<0.1%
Smooth Lumpsucker	Aptocyclus ventricosus	4.7	<0.1%	2	<0.1%
Flathead sole	Hippoglossoides elassodon	2.6	<0.1%	5	<0.1%
Northern smoothtongue	Leuroglossus schmidti	2.5	<0.1%	136	0.2%
Shrimp unident.	Decapoda (order)	2.4	<0.1%	538	0.9%
Pink salmon	Oncorhynchus gorbuscha	0.6	<0.1%	1	<0.1%
Pacific herring	Clupea pallasi	0.0	<0.1%	1	<0.1%
Pacific glass shrimp	Pasiphaea pacifica	0.0	<0.1%	17	<0.1%
Capelin	Mallotus villosus	0.0	<0.1%	1	<0.1%
Total		13,462.4		59,911	

Table 4. Summary of catch by species in 2 bottom trawls conducted during the 2004 pollock echo integration-trawl survey of the Shelikof Strait area.

Common name	Scientific name	Weight (kg)	Percent	Numbers	Percent
Walleye pollock	Theragra chalcogramma	1,185.1	60.3%	2,233	55.0%
Arrowtooth flounder	Atheresthes stomias	464.6	23.6%	336	8.3%
Eulachon	Thaleichthys pacificus	87.9	4.5%	1,137	28.0%
Big skate	Raja binoculata	59.4	3.0%	5	0.1%
Sablefish	Anoplopoma fimbria	43.9	2.2%	24	0.6%
Longnose skate	Raja rhina	35.6	1.8%	4	0.1%
Majestic squid	Berryteuthis magister	33.2	1.7%	88	2.2%
Flathead sole	Hippoglossoides elassodon	22.6	1.2%	52	1.3%
Alaska skate	Bathyraja parmifera	13.8	0.7%	7	0.2%
Pacific halibut	Hippoglossus stenolepis	4.3	0.2%	2	<0.1%
Rex sole	Glyptocephalus zachirus	4.2	0.2%	21	0.5%
Roughshoulder skate	Raja badia	4.0	0.2%	1	<0.1%
Dover sole	Microstomus pacificus	2.3	0.1%	3	0.1%
Sidestripe shrimp	Pandalopsis dispar	1.2	0.1%	69	1.7%
Pacific ocean perch	Sebastes alutus	1.1	0.1%	1	<0.1%
Tanner crab	Chionoecetes bairdi	0.4	<0.1%	3	0.1%
Wattled eelpout	Lycodes palearis	0.3	<0.1%	1	<0.1%
Common mud star	Ctenodiscus crispatus	0.2	<0.1%	45	1.1%
Frusitriton sp.	Frusitriton sp.	0.2	<0.1%	2	<0.1%
Longsnout prickleback	Lumpenella longirostris	0.2	<0.1%	3	0.1%
Pacific herring	Clupea pallasi	0.2	<0.1%	1	<0.1%
Neptunea sp.	Neptunea sp.	0.2	<0.1%	2	<0.1%
Oregon triton	Fusitriton oregonensis	0.1	<0.1%	2	<0.1%
Hermit crab unident.	Paguridae	0.1	<0.1%	4	0.1%
Pandalid shrimp unident.	Pandalid sp.	0.0	<0.1%	4	0.1%
Natica clausa	Natica clausa	0.0	<0.1%	2	<0.1%
Shrimp unident.	Decapoda (order)	0.0	<0.1%	5	0.1%
Squid unident.	Teuthoidea (order)	0.0	<0.1%	1	<0.1%
Careproctus sp.	Careproctus sp.	0.0	<0.1%	1	<0.1%
Total		1,965.0		4,059	

Table 5. Summary of catch by species in 4 midwater trawls conducted during the 2004 pollock echo integration-trawl survey of the Gulf of Alaska shelf break near Chirikof Island.

Common name	Scientific name	Weight (kg)	Percent	Numbers	Percent
Walleye pollock	Theragra chalcogramma	2,890.9	99.1%	3,999	96.1%
Pacific ocean perch	Sebastes alutus	16.4	0.6%	26	0.6%
Jellyfish unident.	Scyphozoa (class)	3.8	0.1%	7	0.2%
Shortraker rockfish	Sebastes borealis	3.1	0.1%	2	<0.1%
Rougheye rockfish	Sebastes aleutianus	3.0	0.1%	2	<0.1%
Myctophidae	Myctophidae	0.5	<0.1%	62	1.5%
Northern smoothtongue	Leuroglossus schmidti	0.1	<0.1%	14	0.3%
Salps unident.	Thaliacea	0.1	<0.1%	3	0.1%
Eulachon	Thaleichthys pacificus	0.1	<0.1%	2	<0.1%
Lamprey unident.	Lampetra sp.	0.1	<0.1%	2	<0.1%
Squid unident.	Teuthoidea	0.1	<0.1%	13	0.3%
Shrimp unident.	Decapoda (order)	0.1	<0.1%	26	0.6%
Ctenophora (phylum)	Ctenophora (phylum)	0.0	<0.1%	2	<0.1%
Total		2,918.1		4,160	

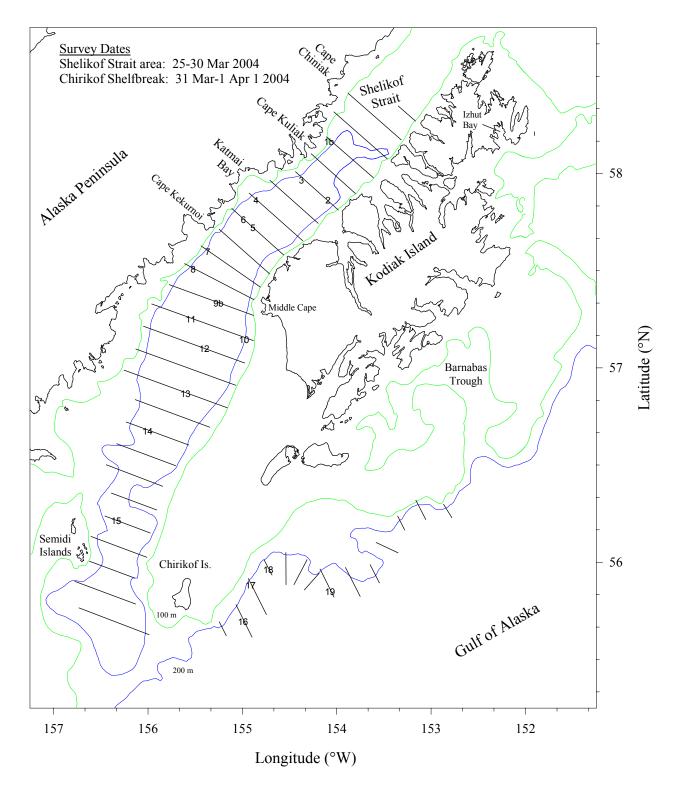


Figure 1. Transect lines and locations of midwater and bottom trawl hauls conducted during the early spring 2004 echo integration-trawl survey of the Shelikof Strait area and the Gulf of Alaska shelf break near Chirikof Island.

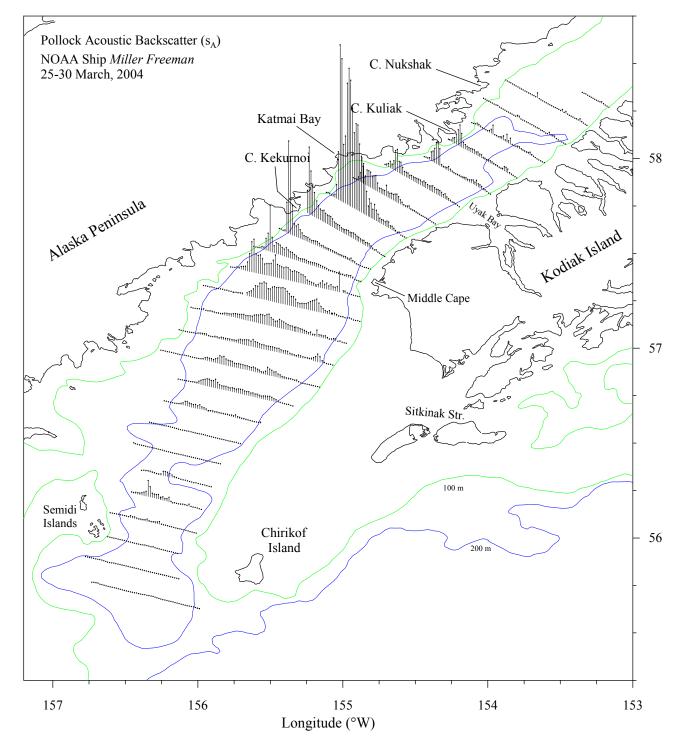


Figure 2. Relative pollock backscatter (s_A) attributed to near-bottom layers along transects from the early spring 2004 echo integration-trawl survey of the Shelikof Strait area.

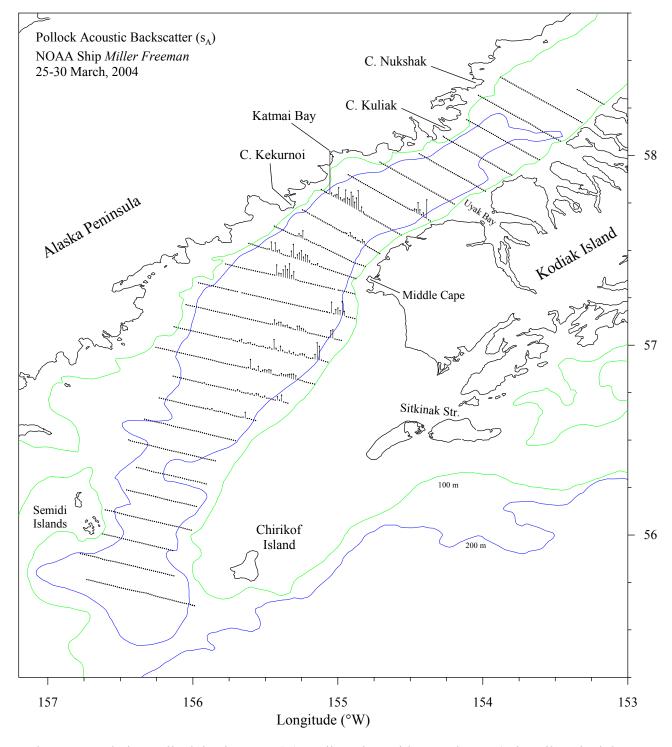


Figure 3. Relative pollock backscatter (s_A) attributed to mid-water layers (primarily subadult pollock) along transects from the early spring 2004 echo integration-trawl survey of the Shelikof Strait area.

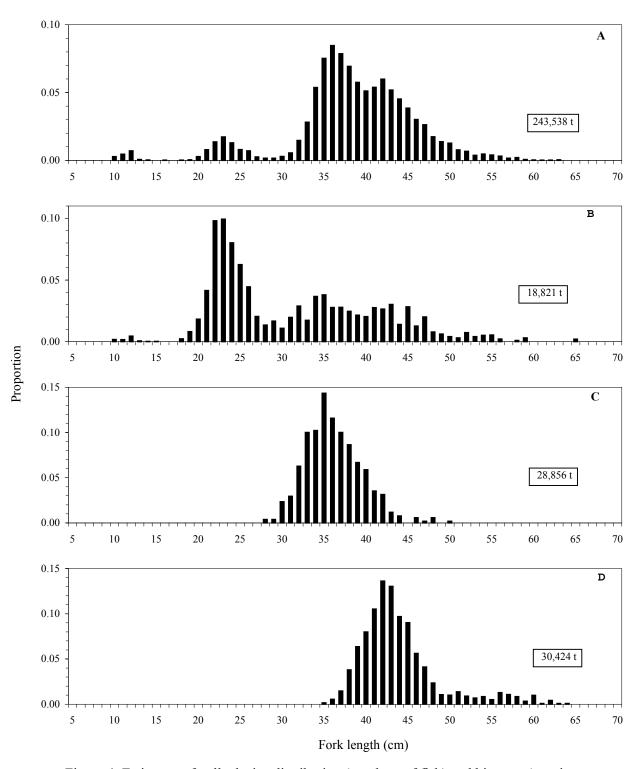


Figure 4. Estimates of pollock size distribution (numbers of fish) and biomass (metric tons (t)) for near-bottom layers (A) from Cape Chiniak to 40 nm southwest of Middle Cape and (B) from 40 nm southwest of Middle Cape to the southern end of the survey area, (C) midwater layers in the Shelikof Strait sea valley, and (D) near Chirikof Island for the early spring 2004 echo integration-trawl survey in the Gulf of Alaska.

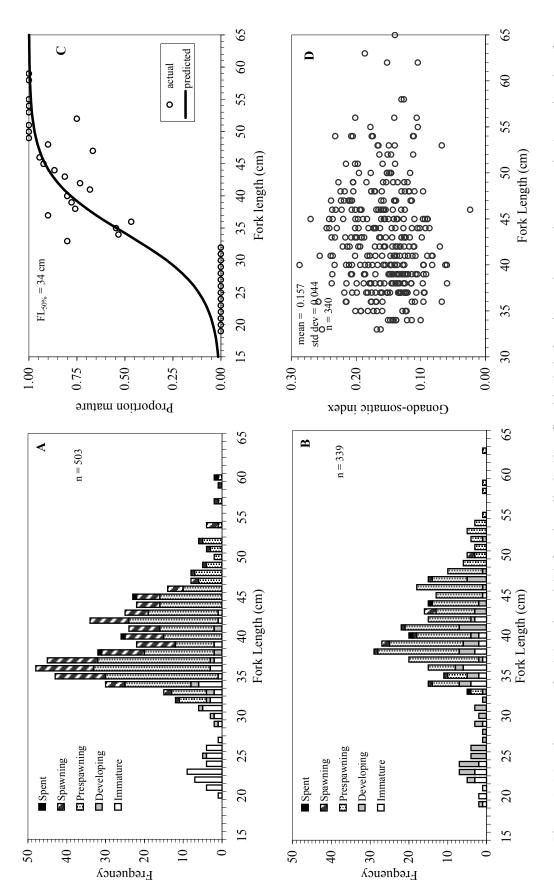


Figure 5. Maturity stages for (A) male and (B) female pollock, (C) a fitted logistic function and proportion mature by 1-cm size class for female pollock. and (D) average gonadosomatic index for pre-spawning females examined during the early spring 2004 echo integratontrawl survey of Shelikof Strait in the Gulf of Alaska.

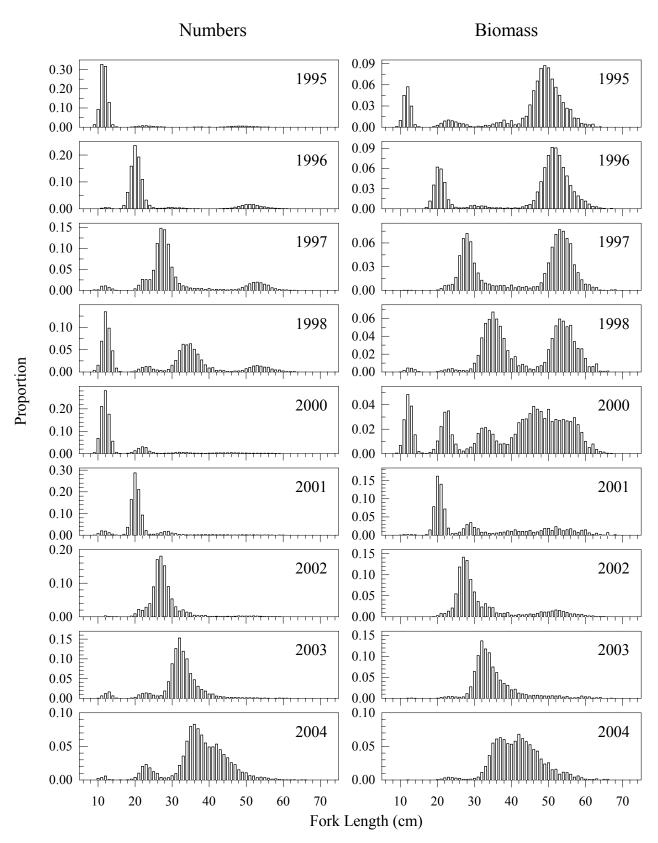


Figure 6. Annual pollock size composition estimates for the Shelikof Strait area based on echo integration-trawl surveys conducted from 1995 to 2004. Note: area was not surveyed in 1999.

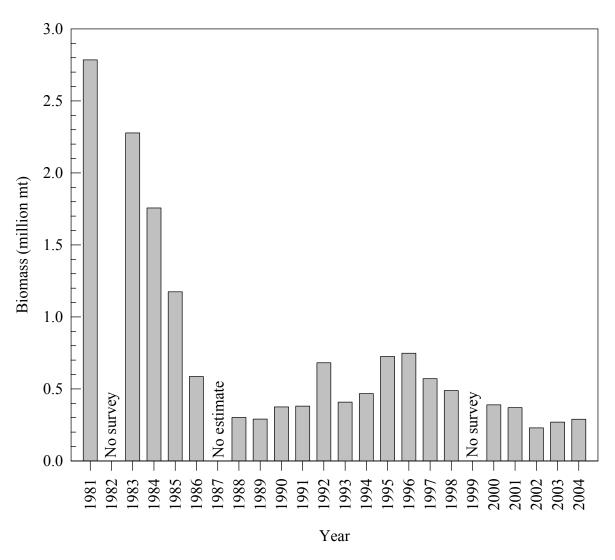


Figure 7. Summary of annual pollock biomass estimates based on echo integration-trawl surveys of the Shelikof Strait area.

Pollock Acoustic Backscatter (s_A) NOAA Ship *Miller Freeman* 31 March-1 April 2004

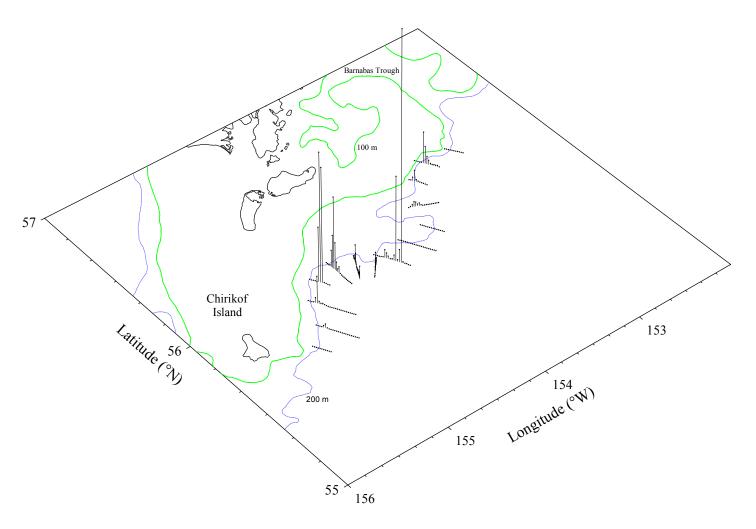


Figure 8. Relative pollock backscatter (s_A) along transects from the early spring 2004 echo integration-trawl survey of the Gulf of Alaska shelf break near Chirikof Island.

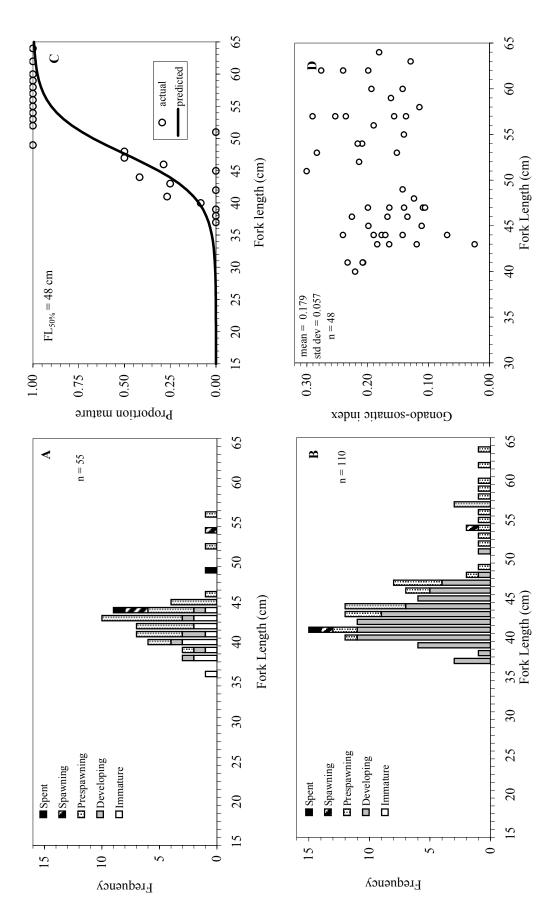


Figure 9. Maturity stages for (A) male and (B) female pollock, (C) a fitted logistic function and proportion mature by 1-cm size class for female pollock. and (D) average gonadosomatic index for pre-spawning females examined during the early spring 2004 echo integratontrawl survey of the Chirikof Island area in the Gulf of Alaska.

